

Innovative process for the synthesis of vanadyl pyrophosphate as a highly selective catalyst for n-butane oxidation.

ABSTRACT

Vanadyl pyrophosphate (VPO) catalysts are used for the selective oxidation of light alkanes, which are based on vanadyl hydrogen phosphate hemihydrate ($\text{VOHPO}_4 \cdot 0.5\text{H}_2\text{O}$) as the precursor. Catalyst precursor with well-defined crystal size has been successfully synthesized for the first time, using a simple one-step high-pressure autoclave that was surfactant-free and water-free method with significantly lower temperature and shorter reaction time. $\text{VOHPO}_4 \cdot 0.5\text{H}_2\text{O}$ was prepared from V_2O_5 using an isobutanol, 1-pentanol, 1-heptanol and 1-decanol as both solvent and reducing agent at elevated temperatures (100, 120, and 150°C). This new method significantly reduced the preparation time and lowered production temperature (50%) of catalyst precursor ($\text{VOHPO}_4 \cdot 0.5\text{H}_2\text{O}$) when compared to conventional hydrothermal synthesis methods. $\text{VOHPO}_4 \cdot 0.5\text{H}_2\text{O}$ can be obtained at temperature far below 150°C . It was found that the presence of 1-heptanol and 1-decanol in the reaction mixtures is crucial for obtaining a well-defined crystal size of precursor phase and solely generated impurity, $[\text{VO}(\text{H}_2\text{PO}_4)_2]$. Our findings show that both the phase composition and morphology of vanadium phosphate can be influenced by the use of different reducing agent and temperature during the preparation process. This new methodology produces catalysts with a much higher surface area (ca. $23\text{m}^2\text{g}^{-1}$) compared with those materials prepared by slow hydrothermal synthesis (ca. $9.5\text{m}^2\text{g}^{-1}$). Finally, the yield of maleic anhydride was significantly increased from 21.3% for conventional catalyst to 37.9% for the new solvothermal catalyst.

Keyword: Vanadyl hydrogen phosphate hemihydrate; Vanadyl pyrophosphate catalysts; Solvothermal synthesis; High-pressure autoclave; n-Butane oxidation.